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TITLE: "METHOD FOR THE OPERATION OF A MAGNETIC RESONANCE APPARATUS FOR FUNCTIONAL IMAGING AS WELL AS A MAGNETIC RESONANCE APPARATUS FOR THE IMPLEMENTATION OF THE METHOD"

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S I R:

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Priority Document concerning the Submission
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Applicant/patent holder:	Siemens Aktiengesellschaft, München/DE
Title:	Method for operation of a magnetic resonance apparatus for functional imaging as well as a magnetic resonance apparatus for the implementation of the method
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The attached pieces are a correct and precise reproduction of the original documents of this application.

München, the 6th September 2001
German Patent and Trademark Office
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METHOD FOR THE OPERATION OF A MAGNETIC RESONANCE APPARATUS FOR FUNCTIONAL IMAGING AS WELL AS A MAGNETIC RESONANCE APPARATUS FOR THE IMPLEMENTATION OF THE METHOD

The invention concerns a method for the operation of a magnetic resonance apparatus for functional imaging, in which a plurality of images are acquired sequentially, alternating in succession, without and with a targeted stimulation of the examination subject.

The method for functional imaging offers the possibility of being able to examine and observe body or organ functions over a longer time span in order to obtain in this manner information about potential malfunctions of the examination region. A plurality of image sequences are successively acquired in succession within the framework of these examinations, whereby either a targeted stimulation of the examination subject ensues or not within a respective sequence. As a result of the targeted stimulation, stimulation-dependent differences appear in the acquired images, these differences being worked out within the framework of the evaluation ensuing after the acquisition of a respective image. One example of an examination method using functional imaging is the BOLD measurement (blood oxygen level dependent) using a magnetic resonance apparatus, in which activity images of the brain of the patient are registered. During one part of the measurements, the brain of the patient is hereby stimulated, for example as a result of finger movement, acousto-optical signals, electrical pulses, etc.; no stimulation ensues during the other part of the measurements. In the framework of the evaluation, the obtained different measurements are correlated against an evaluation correlation value. A measure for the stimulation of defined brain areas of the patient is obtained from this evaluation, whereby the stimulated brain areas appear via clearly brighter regions in the evaluation image.

In known methods, the evaluation ensues directly after a measurement or, respectively, acquisition of an image. This evaluation is based on the relevant information known at this moment as to whether the respective image was acquired with or without stimulation and potential information concerning the stimulation, as well as the respective evaluation correlation value. However, problems arise when a repeated evaluation should ensue at a later point in time. It is not possible, namely, to exactly associate the image-related, relevant information, such as a stimulation phase underlying the acquisition as well as the information about the stimulation itself and the evaluation correlation value, with the respective image.

The invention is therewith based on the problem of specifying a method that enables a later or, respectively, repeated evaluation, and therewith an evaluation of the examination result at any time.

To solve this problem, in a method of type cited above it is inventively provided that an information value that indicates whether the image was acquired during a phase with or without stimulation, at least one image-related stimulation value and at least one image-related evaluation correlation value is [sic] stored for every image.

Via the inventive storing of all exposure-relevant and evaluation-relevant information for each image, the attending physician can undertake the first or repeated evaluation at an arbitrary later point in time, since all relevant information are available to him together with the image data set. The problems with regard to the exact association of the exposure-relevant and evaluation-relevant information with the images, as this is the case in the prior art, advantageously do not exist in the inventive method due to the compulsory, storage-conditional merging of the image data with this information.

Information describing the type and/or intensity and/or duration of the stimulation and/or the stimulation points in time can be inventively stored as stimulation value. Thus any information that in any way whatsoever possesses content relevant for the evaluation and that is to be taken into consideration in the framework of the evaluation can thus be employed as a stimulation value. For example, the brightness of the optical stimulation source, the volume of the acoustic stimulation source, pressure exerted on the examination subject by the stimulation source given a contact stimulation, the pulse intensity of an electrical stimulation source or an operating parameter of the stimulation source specifying a measure for this can be employed as a stimulation value describing the intensity of the stimulation. Insofar as stimulation sources that allow a combined stimulation (for example, an acousto-optical stimulation) are employed, of course, combined stimulation values can also be stored. In addition to this, naturally, there possibility also exists to use stimulation sources other than those mentioned merely by way of example, or, respectively, to store stimulation values other than those described.

A time-related correlation curve is inventively employed for evaluation, whereby a value of the correlation curve lying at the point-in-time of the respective image acquisition is used as an evaluation correlation value. This correlation curve, which is selected by the examining physician as an ideal curve and which forms the basis of an initial evaluation during the image acquisition, shows, for example, a sine curve with a time scale as abscissa. The value of the correlation curve corresponding to the point in time of the exposure is now determined at the respective acquisition times of an image and is co-stored as an evaluation correlation value. In this manner, the time-related evaluation correlation value for each image point of an image is obtained from the correlation curve, whereby the same correlation curve forms the basis for all image points of an image as well as for all acquired images.

It can furthermore be provided that, in addition to the stimulation phase, it is also indicated by means of the information value whether the respective image is an

image to be ignored within the framework of the evaluation. It is sometimes necessary, for example, to ignore the two first and the two last images that are acquired within a phase, since the stimulation and response relationships of the examination region, for example of the brain, change within this time span, for which reason the image information obtained here sometimes holds no relevant information content within the framework of the evaluation.

In addition to the inventive method, the invention also concerns a magnetic resonance apparatus suitable for the implementation of the method according to any of the preceding claims [sic].

Further advantages, features and details of the invention derive from the exemplary embodiment described in the following as well as using the drawing.

The Figure schematically shows the sequence of the inventive method or, respectively, the operation of an inventive magnetic resonance apparatus. An examination subject 1 is shown that is located in a magnetic resonance apparatus 2. For example, here the activity of the brain given an optical stimulation should be investigated. For this purpose, provided is a stimulation source 3 in the form of a light source 4 whose operation us triggered via an external device 5. The light source 4 is turned on and off in alternation corresponding to the curve T. The on duration Δt_m as well as the off duration Δt_o are, for example, respectively 10 s.

A plurality of images within the different stimulation phases are now acquired with the magnetic resonance apparatus 2. In the shown example, respectively five images B are acquired per phase, i.e. with a given stimulation as well as without stimulation. The image exposure is triggered corresponding to the temporal triggering of the stimulation source. This makes it possible to associate an information value with respect to the respective stimulation phase within which the image B was acquired with each image B. In addition, by means of the information value it can be specified whether the respectively acquired image is to

be ignored or not within the framework of the evaluation. In the shown example, the information value sequence reads "IAAAI-IBBBI-IAAAI-...", whereby A = actively stimulated phase, B = non-stimulated phase, I = ignore image. Of the five images acquired per phase, thus, the first and last are note considered in the framework of the evaluation; the three remaining images are evaluated.

As stated, the acquisition of the images B is triggered dependent on the stimulation. In the illustrated exemplary embodiment, five images are acquired per stimulation phase at the times t_{m1}, t_{m2},...,t_{m5}, t_{o1}, t_{o2},....,t_{o5}, t_{m6}, t_{m7},... (t_m = with stimulation; t_o = without stimulation). Furthermore, a first evaluation ensues after the acquisition of each individual image B. In the framework thereof, each individual image and, within this individual image, each individual image point is correlated with reference to a correlation curve K. The correlation curve is determined by the examining physician before the measurement. In the shown example, the correlation is implemented using a sinusoidal correlation curve K since the brain does not supply a step response to an external stimulus, but rather rises slowly up to a maximum of approximately 2 sec and then, upon shut-off, likewise requires a certain time until the signal has decayed. Within the framework of the evaluation, a corresponding, time-related evaluation correlation value k_{m1}, k_{m2},..., k_{m5}, k_{o1}, k_{o2},..., k_{o5}, k_{m6},... is now selected for each exposure point in time t_{m1}, t_{m2},...,t_{o1}, t_{o2},... regardless of the phase. The evaluation now supplies a value that represents a measure for the difference that the respective image point signal exhibits with regard to the value of the correlation curve. A statistical evaluation thus ensues with regard to the images acquired within the measurement (for example, 100 images overall can be acquired within a measurement; naturally, more images can also be acquired); at the end of said statistical evaluation an overall image is present that shows the active zones of the brain. The active zones of the brain result statistically via the consideration of the differences inherent in the picture elements over the total number of the acquired images. The stimulated brain zones appear using clearly brighter areas within the final image.

Finally, each individual image B and a family of information thereto are stored in a storage region 6 of the magnetic resonance apparatus 2, these enabling a later evaluation of the image series since the operating, stimulation and evaluation parameters effected by the examining physician during the measurement and the initial evaluation are known per individual image. In the shown example, the exposure point in time t_{m1}, the correlation value k_{m1} related to the exposure point in time, the phase information value I as well as the stimulation value T_w (for example, the brightness of the light source 4) are stored for the first image B. The exposure point in time t_{m2}, the correlation value k_{m2}, the phase information value A and the stimulation value T_w are stored for the second acquired image, etc.

Naturally, it is also possible to also store further image-related information per image insofar as these are relevant for a subsequent evaluation.

Patent Claims

1. Method for the operation of a magnetic resonance apparatus for functional imaging, in which a plurality of images are acquired sequentially, alternating in succession, without and with a targeted stimulation of the examination subject, whereby an information value that indicates whether the image was acquired during a phase with or without stimulation, at least one image-related stimulation value and at least one image-related evaluation correlation value is [sic] stored for every image.

2. Method according to claim 1,
characterized in that
information describing the type and/or intensity and/or duration of the stimulation and/or describing the stimulation points in time is stored as a stimulation value.

3. Method according to claim 2,
characterized in that
the brightness of the optical stimulation source; the volume of the acoustic stimulation source; the pressure exerted by the stimulation source on the examination subject given a contact stimulation; the pulse intensity of an electrical stimulation source; or an operating parameter of the stimulation source specifying a measure for this can be used as a stimulation value describing the intensity.

4. Method according to claim 2 or 3,
characterized in that
a time-related correlation curve is used for the evaluation, whereby a value of the correlation curve lying at the point in time of the respective image acquisition is used as an evaluation correlation value.

5. Method according to one of the preceding claims,
characterized in that,

in addition to the phase, by means of the information value it is also indicated whether the respective image is an image to be ignored within the framework of the evaluation.

6. Magnetic resonance apparatus suitable for the implementation of the method according to one of the preceding claims.

Abstract

Method for the operation of a magnetic resonance apparatus for functional imaging as well as a magnetic resonance apparatus for the implementation of the method

Method for the operation of a magnetic resonance apparatus for functional imaging, in which a plurality of images are acquired sequentially, alternating in succession, without and with a targeted stimulation of the examination subject, whereby an information value that indicates whether the image was acquired during a phase with or without stimulation, at least one image-related stimulation value and at least one image-related evaluation correlation value is [sic] stored for every image.

Figure 1